OCR
Oxford Cambridge and RSA

Tuesday 19 October 2021 – Afternoon

A Level Biology A

H420/03 Unified biology

Time allowed: 1 hour 30 minutes

You can use:
- a ruler (cm/mm)
- a scientific or graphical calculator

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H420/03

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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Answer **all** the questions.

1 **(a)** The figure below shows a light micrograph of an insect's gas exchange system.



Name the structures labelled **A** and **B** in the figure.

A .....

B .....

[2]

(b) Fish use gills as specialised gas exchange surfaces.

(i) In ventilation, water moves into the buccal cavity, across the gills and out of the opercular cavity.

Complete the table by placing ticks (✓) in the appropriate boxes to show which of the processes occur at each stage of ventilation.

	Mouth closes	**Buccal cavity floor lowers**	**Operculum opens**	**Highest rate of oxygen diffusion into the blood**
Water moves into the buccal cavity				
Water moves across the gills and out of the opercular cavity				

[2]

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(ii) A student described how they dissected a fish to view the gills:

'I held the fish on a cutting board with one hand. I used scissors and a scalpel to carefully cut from the mouth to the tail, down the ventral side of the fish. I was able to split the fish into two halves and view the gills on the inside of the mouth.'

Suggest **one** improvement to the student's method that would allow them to observe the gills more easily.

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..... **[1]**

(c) Lungs are the specialised gas exchange surfaces in mammals. Dogs are mammals.

A disease called canine pulmonary fibrosis (CPF) can affect lung function in dogs. CPF can reduce the tidal volume of a dog's lungs.

(i) The West Highland Terrier develops CPF more often than other breeds of dog.

The lung function of a West Highland Terrier was tested. At rest, its ventilation rate was $1.44\,dm^3\,min^{-1}$ and its breathing rate was 24 breaths min^{-1}.

Calculate the tidal volume of the West Highland Terrier in cm^3.

Tidal volume = ... cm^3 **[1]**

(ii) Explain how the high occurrence of CPF in West Highland Terriers could have been a result of artificial selection.

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..... **[1]**

(iii) Explain how DNA sequencing could help scientists understand how the West Highland Terrier's genes affect its probability of developing CPF.

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..... **[2]**

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(iv) Another disease that affects dogs is caused by parvovirus. Dogs can be vaccinated against parvovirus at six weeks of age.

Suggest what the parvovirus vaccine is likely to contain.

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..... **[1]**

(v) Dogs need a booster vaccination against parvovirus when they are one year old.

Explain why a booster vaccination is needed.

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..... **[1]**

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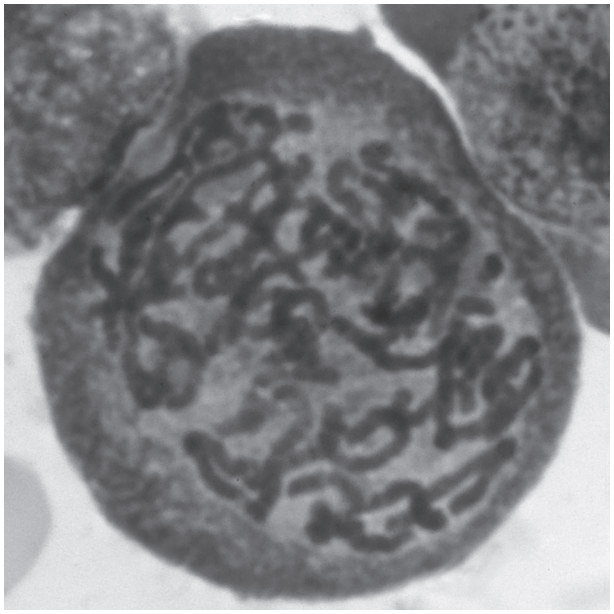
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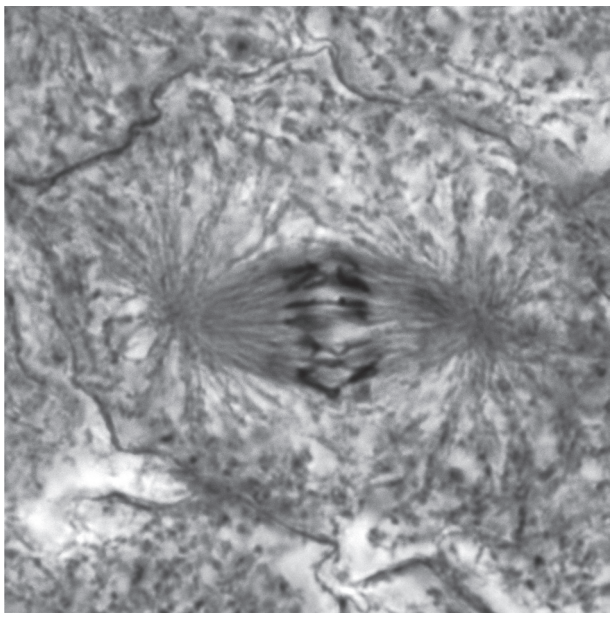
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2 **(a)*** **Fig. 2.1** shows three images, **C** to **E**, of animal cells undergoing mitosis.

C



D



E

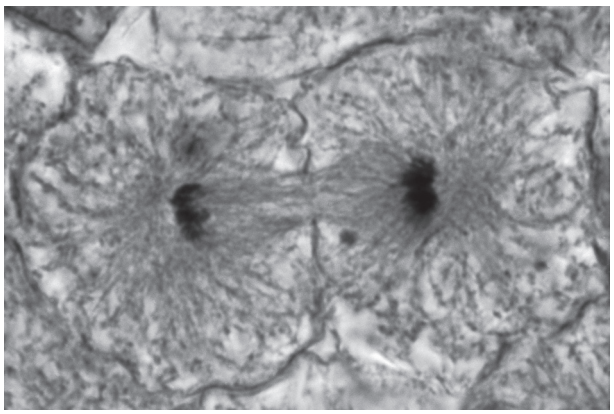


Fig. 2.1

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Describe the events taking place in cells **C**, **D** and **E**.

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..... **[6]**

Additional answer space if needed.

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(b) The eukaryotic cell cycle is regulated by three checkpoints. Mutations can occur in genes that control the cell cycle checkpoints.

Scientists recorded observations of two different tissues.

(i) In one tissue, the scientists found a genetic mutation that stopped the metaphase checkpoint from working.

Suggest an abnormality the scientists might observe in the cells of this tissue.

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..... **[1]**

(ii) In the other tissue, the scientists observed cells with chromosomes that had been replicated despite containing damaged DNA.

Suggest which cell cycle checkpoint is no longer working in this tissue **and** justify your answer.

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..... **[1]**

(c) Mitosis does not occur in bacteria. Bacterial cells divide using binary fission. Binary fission is shown in **Fig. 2.2**.

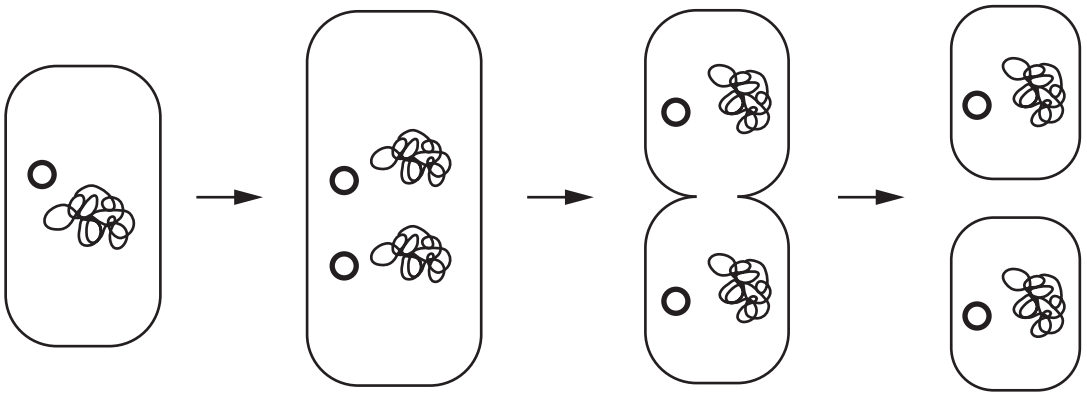


Fig. 2.2

Bacteria do not have a nucleus.

Describe **two other** differences between how DNA is separated during binary fission and mitosis.

1 .....

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2 .....

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[2]

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(d) Scientists recorded the population growth of bacteria in a closed culture. The scientists added various nutrients to the culture, including nitrate (NO_3^-).

Fig. 2.3 shows the growth curve of the bacterial population.

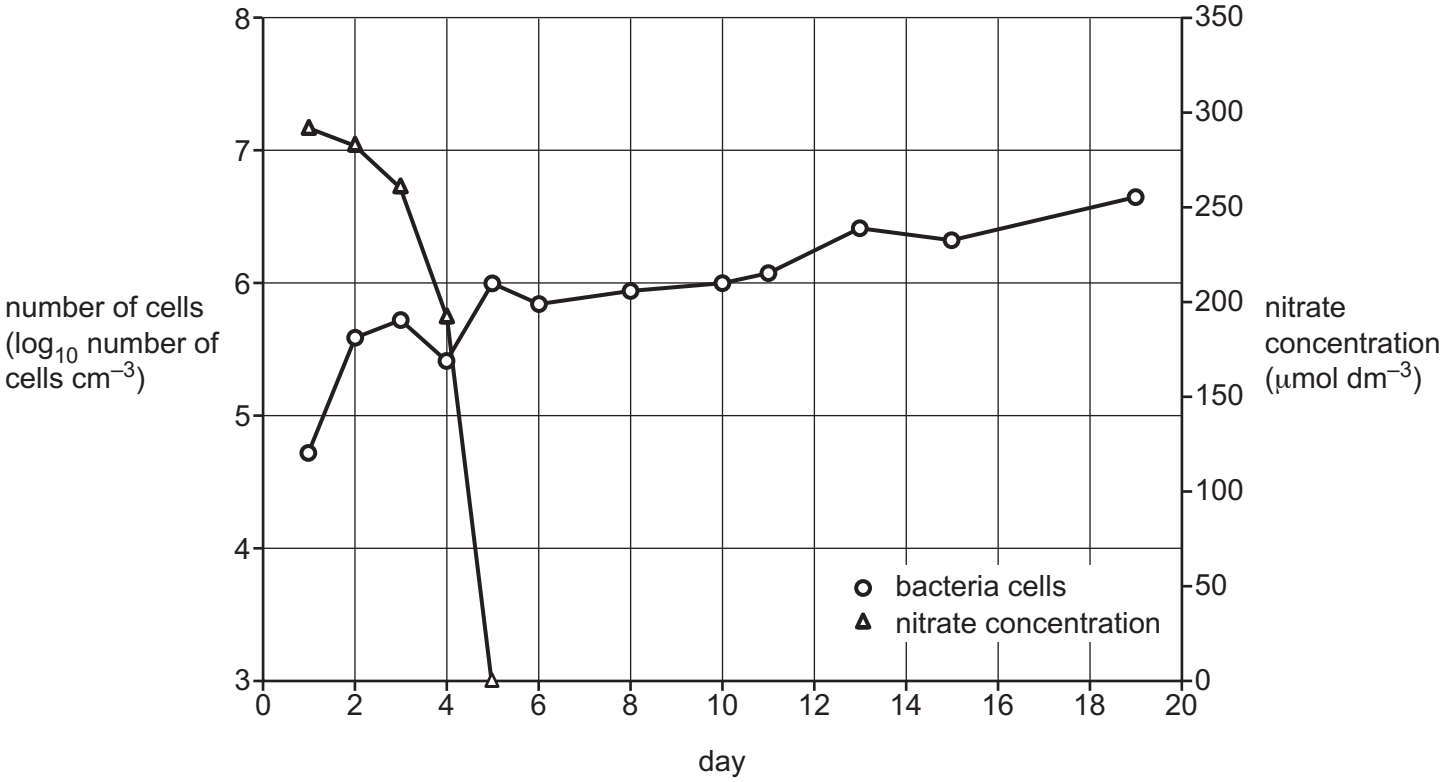


Fig. 2.3

(i) A student looked at **Fig. 2.3** and made the following statement:

'The bacterial growth curve in **Fig. 2.3** looks very different from a standard growth curve for bacterial populations.'

Use evidence from **Fig. 2.3** to evaluate the student's statement.

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..... **[4]**

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(ii) Calculate the total number of bacterial cells that would have been present in a 50 cm^3 container on day 1.

Write your answer in standard form.

Number of bacterial cells = ... **[3]**

(iii) Describe a laboratory procedure that the scientists might have used to estimate the bacterial population.

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..... **[2]**

(e) The passage below describes some uses of microorganisms in biotechnology.

Complete the passage by writing the most appropriate words in the blank spaces.

Microorganisms have many characteristics that make them useful in biotechnology. These characteristics include ..... life cycles and low energy requirements. Species such as *Pseudomonas putida* and *Dechloromonas aromatica* can be used for bioremediation to remove ..... from water. Other species of bacteria are used to manufacture drugs, such as insulin. Antibiotics, which are secondary ..... , are produced by fungi and are used to kill pathogenic bacteria.

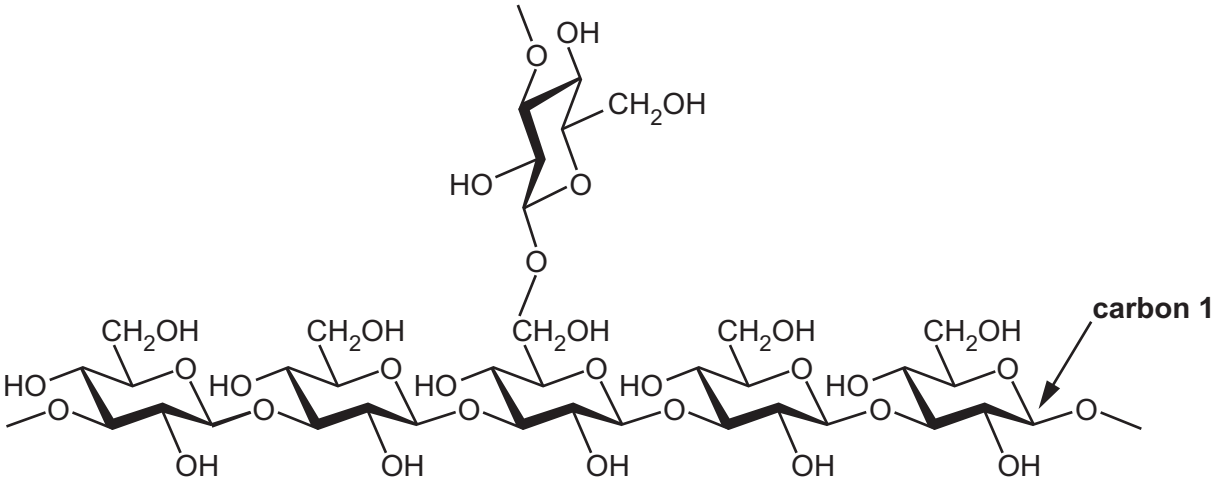
[3]

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3 Callose is a polysaccharide produced by plants.

(a) Callose is formed from β-glucose monomers.

The figure below shows a section of callose.



Describe the differences between the structures of callose and cellulose.

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..... **[2]**

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(b)* Plants produce callose in response to pathogenic infection, injury and changes in environmental temperature. Scientists wanted to investigate the effect of temperature on callose production.

Outline a valid plan that could be used to investigate the effect of temperature on callose production in plants.

You should include a suggestion for how callose production could be observed.

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..... **[6]**

Additional answer space if needed.

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(c) Callose production reduces the spread of pathogens in plants. The table below lists pathogens that infect plants together with features of the pathogens and examples of the diseases they cause.

Complete the table below by writing the correct answers in the empty boxes.

Type of pathogen	Pathogen has membrane-bound organelles	Pathogen has a cell wall	Example of a plant disease caused by the pathogen
	yes	yes	black sigatoka
			ring rot
virus	no	no	

[3]

(d) Many plants have defensive responses to herbivores.

State **one** example of a response that plants use against herbivory.

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..... **[1]**

(e) Many crop plants are eaten by herbivorous insects. Humans use insecticides to reduce the consumption of crop plants by insects.

Explain why an insecticide might be less effective after being used for many years.

.....

..... **[1]**

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4 **(a)** Some organisms use a disaccharide called trehalose as a respiratory substrate. Trehalose has a similar structure and very similar chemical properties to sucrose.

Suggest how you could test for the presence of trehalose.

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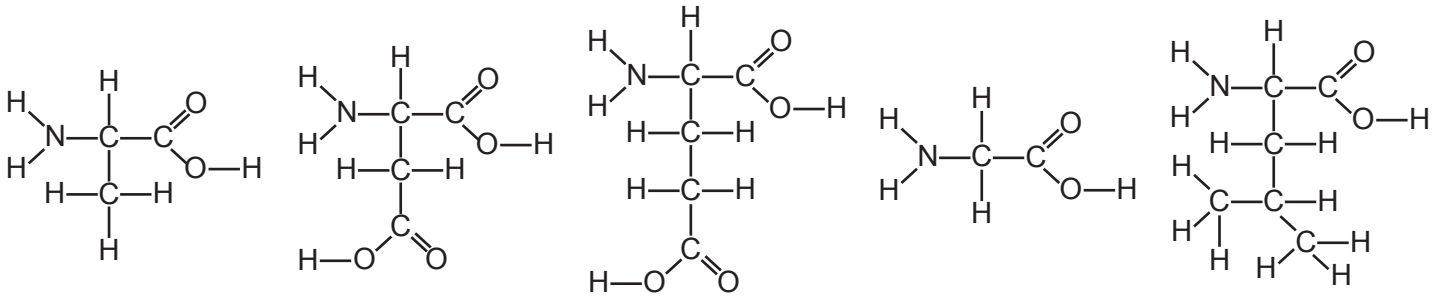
..... **[2]**

Question 4(b) begins on page 16

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(b) Amino acids can be converted to other molecules and used in respiration.

Fig. 4.1 shows the formulae of five amino acids that can be used in respiration.



alanine aspartic acid glutamic acid glycine leucine

Fig. 4.1

Fig. 4.2 shows an outline of the link reaction and the Krebs cycle.

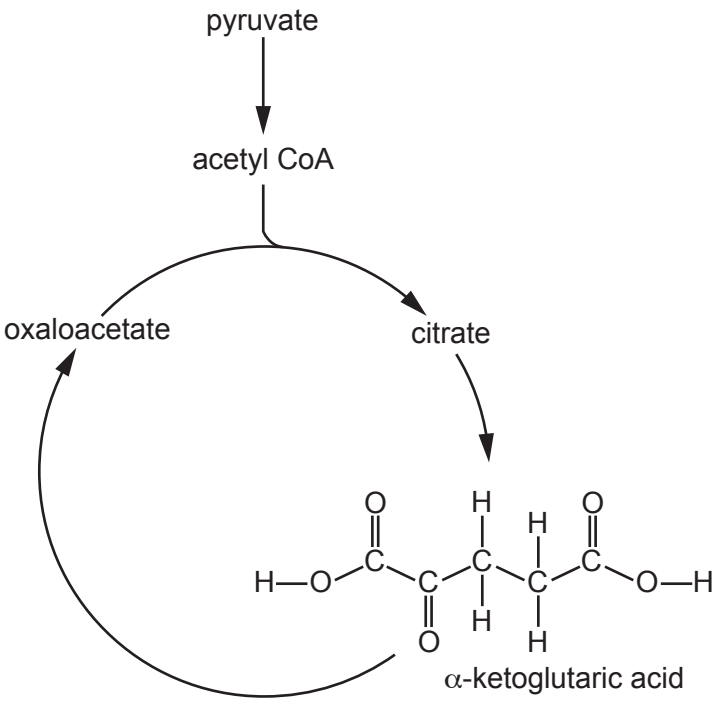


Fig. 4.2

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(i) The table below contains information about three amino acids.

Use **Fig. 4.1** and **Fig. 4.2** and your own knowledge to draw a conclusion about which amino acid is being described.

Write your conclusions and a justification for each conclusion in the table.

Information about amino acid	**Conclusions**	
	Name of amino acid	**Justification**
Converted to pyruvate with the fewest changes		....
Converted to α-ketoglutaric acid with the fewest changes		....
The amino acid with the highest RQ		....

[4]

(ii) Outline the reactions that must occur to convert α-ketoglutaric acid to oxaloacetate in **Fig. 4.2**.

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..... **[2]**

(c) Most ATP is produced in mitochondria by chemiosmosis.

Outline how ATP is produced in mitochondria by chemiosmosis.

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..... **[3]**

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(d) A person's RQ changes when they exercise.

Fig. 4.3 shows how RQ changes with the power a person exerts during exercise. Power, measured in watts (W), increases as the intensity of physical exercise increases.

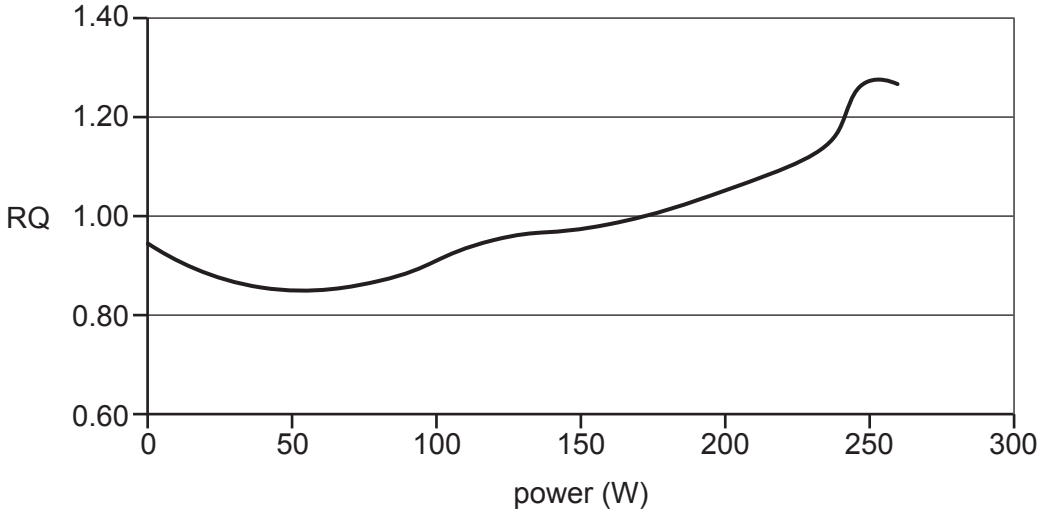


Fig. 4.3

What can you conclude about respiration at 0, 50 and 250 W based on the RQ values?

0 W .....

.....

50 W .....

.....

250 W .....

.....

[3]

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5 **(a)** Amylose is formed from the glucose molecules produced in photosynthesis. **Table 5.1** shows three statements about amylose, which may be true or false.

Complete **Table 5.1** by writing either 'True' or 'False' in the empty boxes provided.

Statement	True or False?
Amylose is soluble	
Amylose is branched	
Amylose is formed by condensation reactions	

[1]

Table 5.1

(b) Light intensity is one factor that affects the rate of photosynthesis.

Fig. 5.1 shows how the rate of photosynthesis varies with light intensity in two plants: a fern species, *Dicksonia antarctica*, and maize, *Zea mays*.

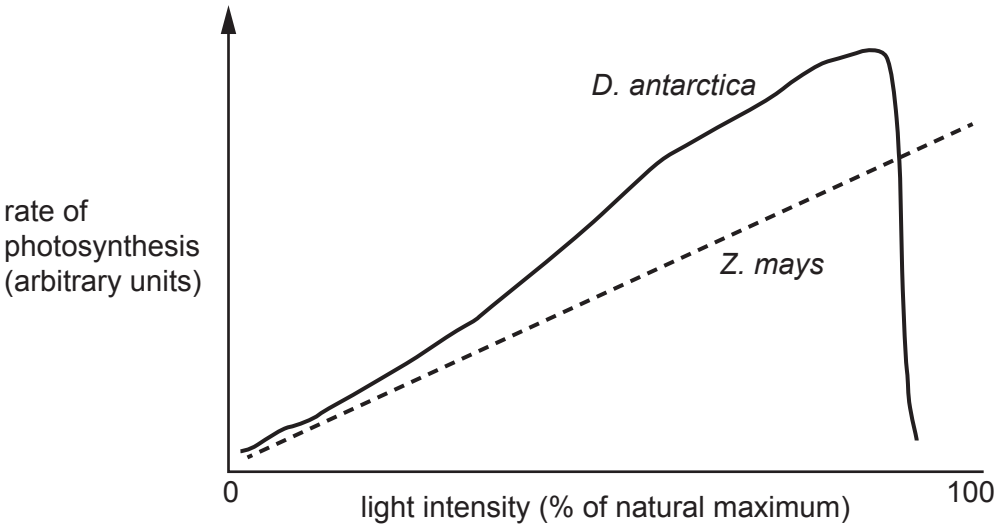


Fig. 5.1

What can you conclude from **Fig. 5.1** about the habitat of *D. antarctica* compared to the habitat of *Z. mays*?

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..... **[2]**

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(c) Water availability can affect the rate of photosynthesis in some plants.

Some students investigated the effect of soil water content on the rate of photosynthesis in two plant species: maize, *Z. mays*, and a xerophyte called *Calotropis procera*.

The students took measurements at six different sites for each species. They measured the water content of the soil and calculated the rate of photosynthesis at each site.

The students' data are shown in **Table 5.2**.

Calotropis procera		***Z. mays***	
Water content of soil (% by volume)	Mean rate of photosynthesis ($\mu mol\, CO_2\, m^{-2}\, s^{-1}$)	Water content of soil (% by volume)	Mean rate of photosynthesis ($\mu mol\, CO_2\, m^{-2}\, s^{-1}$)
12.1	4.2	32.3	21.6
10.0	4.0	29.0	20.2
7.2	6.0	24.5	19.2
4.0	4.1	18.1	16.5
2.5	3.3	15.4	16.8
1.8	2.0	11.6	8.0

Table 5.2

Table 5.3 shows a statistical table for r_s values.

***p* (%)**	**10**	**5**	**1**
n			
5	0.800	0.900	1.000
6	0.657	0.829	0.943
7	0.571	0.714	0.893
8	0.524	0.643	0.833

Table 5.3

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(i) The students investigated the relationship between the water content of soils and mean rate of photosynthesis for the two plants.

Using the values in **Table 5.2**, calculate the Spearman's Rank Correlation Coefficient for water content and rate of photosynthesis in *Z. mays*.

Use the formula:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

r_s = ... **[3]**

(ii) Use **Table 5.3** to decide what the students can conclude from the r_s value you calculated in part **(i)**.

.....

..... **[1]**

(iii) The students calculated the r_s value for water content and rate of photosynthesis in *Calotropis procera* as 0.714.

Use **Table 5.3** to decide what the students can conclude from the r_s value of 0.714.

.....

..... **[1]**

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(d) Photosynthesis can occur in organisms other than plants. These organisms have photosynthetic pigments that are adapted to their habitats.

(i) The cyanobacterium *Acaryochloris marina* lives in an aquatic habitat with many aquatic plant species.

Acaryochloris marina has a high concentration of chlorophyll D in its cells and a relatively low concentration of chlorophyll A.

The absorption spectra of chlorophyll A and chlorophyll D are shown in **Fig. 5.2**.

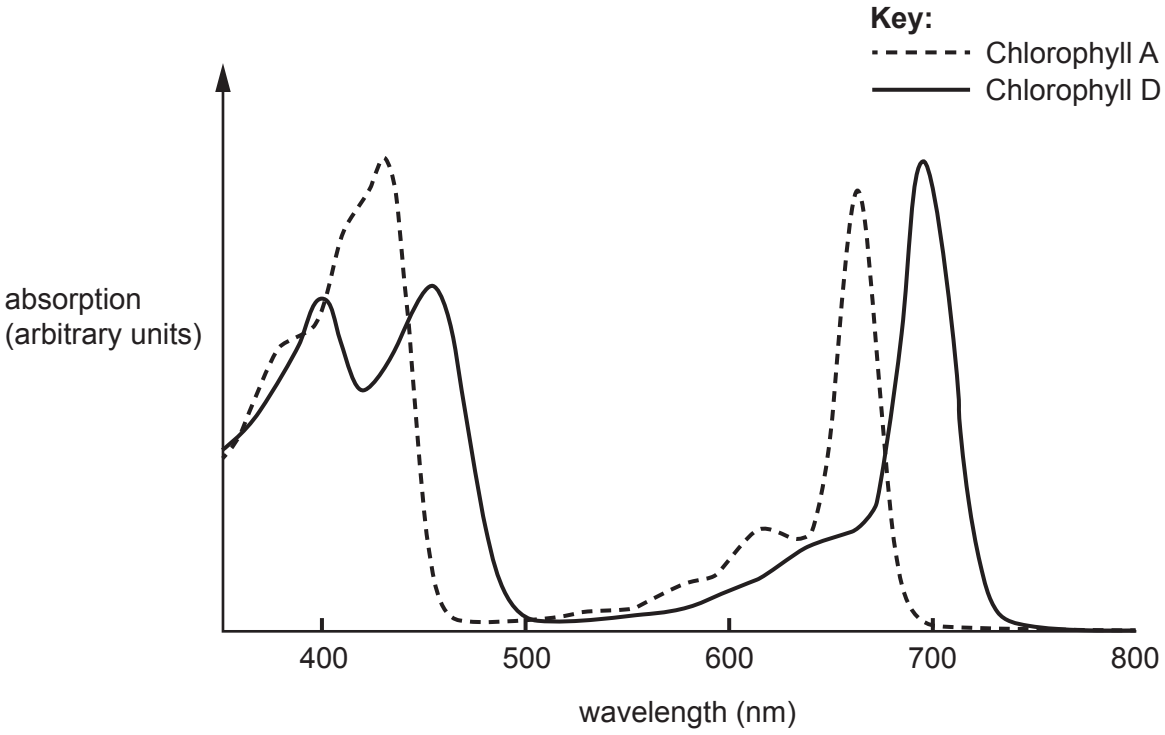


Fig. 5.2

Suggest why having a high concentration of chlorophyll D is an advantage for *Acaryochloris marina*.

.....

..... **[1]**

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(ii) Diatoms are unicellular photosynthetic eukaryotes. Diatoms contain high concentrations of the pigment fucoxanthin.

Fig. 5.3 shows a chromatogram with three pigments, **X** to **Z**.

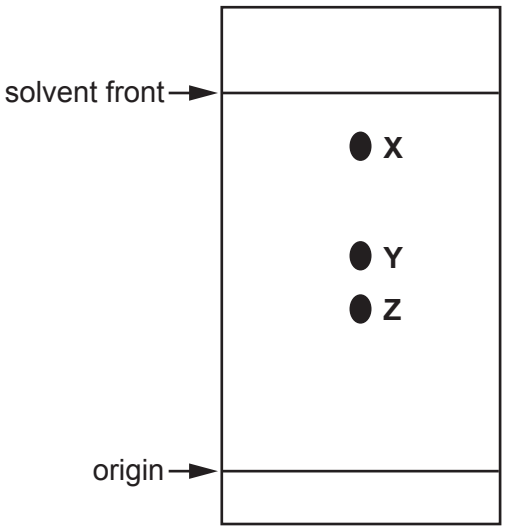


Fig. 5.3

Fucoxanthin has an R_f value of 0.43.

Identify the letter (**X**, **Y** or **Z**) that represents fucoxanthin.

Fucoxanthin = ... **[1]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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